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An Overview of Higher Order Frequency Applications in Communication Systems

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Abstract: *The principal reason for focusing on the higher band is the huge amount of allocated bandwidth around 60 GHz, which can be used to accommodate all kinds of short-range (< 1 km) wireless communication. In addition, 60 GHz front-end technology is emerging rapidly. In order to exploit the 60 GHz band efficiently, an overall network architecture should be worked out that gives the industry wide scope for product differentiation and 60 GHz system design should evolve guiding criteria such as affordability, modularity, scalability, expandability, interoperability and ergonomics.*

Keywords: FCC (Federal Communications Commission), CEPT (Center for Environmental Planning and Technology), MAN (Metropolitan Area network), WPAN (Wireless Personal Area Network), mmWIG (Millimeter Wave Interest Group), ATM (Asynchronous Transfer Mode), WLAN (Wireless Local Area Network), LOS (Line of sight), MMIC (Monolithic Microwave Integrated Circuit).

I. Introduction

In the last few decades, communication technologies have been increasing exponentially from the very beginning of voice communication to today's data communication. Internet and intranet have been used extensively to transfer information globally and locally. The invention of Wireless Local Area Network (WLAN) gets rid of cable connections within a room or a building providing more freedoms in mobility. However, the highest data-rate that can be achieved is 54 Mbit/s among all of the current WLAN standards, which is half of the current 100 Mbit/s Ethernet. Next generation Ethernet will have a data-rate of 1 Gbit/s. apparently, a very-high-speed wireless standard needs to be developed for giga-bit-per-second Ethernet. There are many other applications demanding wireless communication techniques with high data rates if one wants to remove the clumsy high-frequency-cables, e.g. HDTV.

This is where wireless local area network (WLAN) systems come into the picture. Current WLAN products are proprietary systems or based on the IEEE 802.11b standard. These products operate in the industrial, scientific, and medical (ISM) 2400–2483.5 GHz band and provide a (gross) user capacity up to 11 Mb/s. In 1999 the IEEE ratified the WLAN standard

IEEE 802.11a, which provides physical layer input data rates of 6, 9, 12, 18, 24, 36, and 54 Mb/s. In the United States these products operate in the 5.15–5.35 and 5.725–5.825 GHz Unlicensed National Information Infrastructure (UNII) band. High Performance Radio Local

Area Network (HIPERLAN) Type 2, the standard specified by the European Telecommunications Standards Institute (ETSI) project Broadband Radio Access Networks (BRAN), defines the same physical layer with the exception that it provides one additional data rate, 27 Mb/s. In Europe, a license-exempt frequency band at 5.15–5.35 GHz and 5.470–5.725 GHz has been reserved for HIPERLAN.

To transmit such a high data-rate, a wide frequency band is needed. For instance, a bandwidth of 500 MHz is needed for 1 Gbit/s if a QPSK modulation without any error coding overhead is used. If a one-half coding scheme is used, the minimum bandwidth is 1 GHz. On the other hand, the frequency resources at low frequencies have already been allocated to other applications. This pushes the carrier frequency to microwave and millimeter wave. The best frequency candidate for short range communications is around 60 GHz, at a band that it is not suited for long-range communications due to the atmospheric attenuation. In a short range, this attenuation is of no significance. Many counties and districts have marked this band as unlicensed band, those are: Japan, 59.0-66.0 GHz; USA and Canada, 57.05-64.0 GHz; Korea, 57.0-64.0 GHz; Europe, 57.0-66.0 GHz; China, 59.0-66.0 GHz and Australia, 59.4-62.0 GHz.

The basic issues regarding the design and development of wireless access and wireless LAN systems that will operate in the 60 GHz band as part of the fourth-generation (4G) system. The 60 GHz band is of much interest since this is the band in which a massive amount of spectral space (5 GHz) has been allocated worldwide for dense wireless local communications. The article gives an overview of 60 GHz channel characteristics and puts them in their true perspective. The main tenor is that an overall system architecture should be worked out that provides industry with plenty of scope for product differentiation.

The system architecture should feature affordability, scalability, modularity, extendibility, and interoperability. In addition, user convenience and easy and efficient network deployment are important prerequisites for market success. There exists a applications calling for wireless transmission over short distances. Examples of applications, together with estimates of required data rates and cost requirements. The data rate figures refer to individual connections rather than aggregate network capacity, which may be multiples of illustrates that the required data rate for some applications may be hundreds of megabits per second and that the range of data rates is very wide. The large variety of applications indicates that the wireless infrastructure should support real-time traffic with largely varying delay constraints as well as non-real-time traffic with different reliability requirements.

Flexible network solutions are required to accommodate the large number of communicating devices. In particular, the flexibility requirement is prominent in ad hoc network architectures that have multihop capabilities with many different operators in the same areas. Furthermore, it is indicates that in many applications, information integrity plays a vital part and thus should be well secured. The significance of all this is that next to the network capacity required to accommodate the actual application, there is much additional transfer capacity needed for quality of service provisioning and key features such as dynamic resource allocation and routing and security protocols for data integrity and protection against unauthorized access. It is also indicates that many applications require low-cost technology. Third-generation cellular systems will not be based on low-cost technology and will not be able to cope with data rates in excess of 2 Mb/s. Overview of the system under consideration

Why the 60 GHz band is suitable (bit rate, atmospheric attenuation, frequency re-use...)? The package will include comparison between different modulation types and access types with respect to hardware requirements. Assuming one or two applications for deeper penetration, this work will explore the international work that is being done.

II. Methodology

- To focus on optimization techniques that can cope with the particular properties of the 60 GHz communication system.
- Identifying different protocols standards available for communication.
- To refine existing and develop new 60GHz software and hardware reference model specifications and reviewed literature.
- Reference model for 60 GHz communication system model will be developed based upon identified specifications using suitable simulator.
- To implement the pre-layout simulations using H-SPICE.

III. Review of Literature

1. Gaurav Verma et.al., "Design and implementation of router for NOC on FPGA"

This paper proposes router, its components and parameters which affects the entire design. Thus, to validate the functioning of NOC on hardware, router has been designed in VHDL and simulated in Xilinx ISE 14.1 targeting Xilinx XC5VLX30-3 FPGA. The work initiates router using wormhole concept of switching. FPGA platform is served for router implementation using round-robin routing scheme. In every clock cycle, the proposed router encounters the status of FIFO of input ports and each input port priority is calibrated dynamically. The above designed architecture ensures that all input ports are served with justice. The proposed architecture is designed in VHDL using Xilinx tools. Its implementation has been done in ISE design suit 14.1 and the functionality of the design has been verified.

2. Sajad Ahmad Ganiee et. al. "FPGA Design of 8 bit 4×4 Crossbar Switch forMulti Processor System on Chip Using Round Robin Arbitration Algorithm"

The work presents Verilog implementation, modeling and synthesis of 8-bit 4 × 4 crossbar switch for virtual channel router. The crossbar components are widely used in router and switches. A crossbar switch may serve as switching fabric to provide a non blocking network configuration. Mainly crossbar is used as an interconnection network in NoC. Crossbar switch is a fully connected network, where each input is connected to each output. Crossbar switch is of great interest in packet switch designs. In virtual channel router minimum flit size is 8-bit. A arbitration module called DPA cell is designed and 8 bit fabric module for crossbar. As flit size is 8- bit for virtual channel router 8- bit 4 × 4 switch is implemented. In this paper rotating round robin arbitration algorithm with the help of DPA had been also implemented Hence proposed arbiter is suitable for NoC design which needs high speed cross bar switches and router in them. The design is synthesized on Vertex 7 and maximum operating system achieved 1.1 GHz. Using parallel bit data transfer, Using parallel bit data transfer faster data transmission rates are achieved. Critical path delay of 8-bit 4x4 crossbar switch is 4.996ns. also implemented rotating round robin arbitration algorithm with the help of DPA. Round Robin Arbitration scheme guarantees that all input request are treated fairly. Critical path delay is 8-bit 4x4 crossbar switch is 0.876ns (Maximum Frequency: 1142.074MHz).

3. Deivakani M et.al "Design of Efficient Router with Low Power and Low Latency for Network on Chip"

This paper proposes hybrid scheme for Network of Chip (NoC), supports both wired and wireless configurations which aims at obtaining low latency and low power consumption by concerning wired and wireless links between routers. The main objective is to reduce the power consumption is reduced by designing a low power router and latency is reduced by implementing a on-chip wireless communication as express links for transferring data from one subnet routers to another subnet routers. The average packet latency and normalized power consumption of proposed hybrid NoC router are analyzed for various traffic loads as proposed hybrid scheme is tested on various traffic modes such as synthetic and real time environments.

The proposed hybrid NoC router reduces the normalized power over the wired NoC by 12.18% in consumer traffic, 12.80% in AutoIndust traffic and 12.5% in MPEG2 traffic. It also reduces the normalized power over the baseline NoC router by 14.06% in consumer traffic, 14.91% in AutoIndust traffic and 14.61% in MPEG2 traffic. The performance is also analyzed with real time traffic environments using Network simulator 2 tool. The proposed scheme can significantly reduces the latency over the conventional wired NoC router by 30% in shuffle traffic mode, 11.25% in bitcomp traffic mode, 12.85% in transpose traffic mode and 13.3% in bitrev traffic mode. The performance of hybrid NoC router is superior to the conventional baseline and wired NoC router by incorporating wired and wireless subnets in NoC.

4. Nimushakavi S N et.al "A survey on QoS routing techniques used in network on chip"

In this paper author detailing common router techniques and problems with their operating techniques. And suggestion for improving their overall performance.In a NOC surroundings, a silicon CMOS chip fashion designer should recollect the need for an arbiter to remedy conflicts on shared sources (i.E., bus or equivalent communiqué channels) amongst a couple of bus masters (e.G., processors). In a busprimarily based device, processors might be stalled because of bus conflicts. Hence, a high-overall performance arbiter is wanted to clear up bus contentions among bus masters; this sort of fast arbiter can also reduce processor stall time by using shortening arbitration delays. In this work, author analyzed the impact on multiprocessor device-on-chip of various scheduling techniques used in router, displaying the exceptional features of each policy and the study correlation in their effectiveness with the verbal exchange requirements of an application. We have encountered the problems available in all the present schedulers. As a way to acquire our aim of designing congestion free, low latency, excessive velocity scheduler we are able to use DAA because the base of operation and could do FPGA prototyping of the equal thru Verilog HDL to apply it

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IV. General System Overview

The circuit building blocks for the proposed 60 GHz transmitter and receiver is as shown in the Fig 1 below.

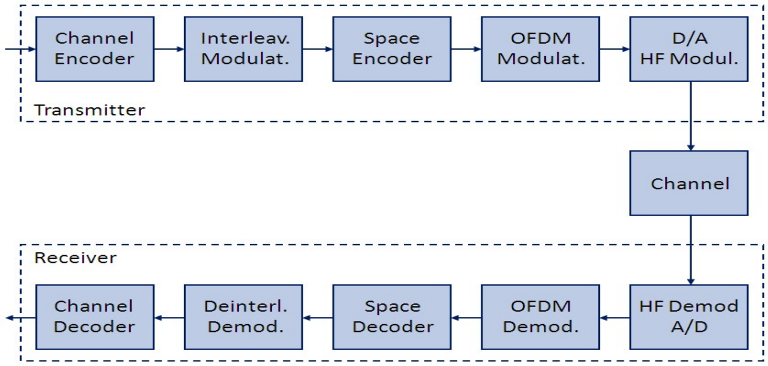

Figure 1: Block Diagram of communication system.

A scenario of a 5/60 GHz dual-band system for professional applications is shown in Fig. b. There is, however, no reason to restrict the application field to particular environments; many probable uses can also be found in indoor areas such as residential environments (Fig. 3), but also in outdoor environments such as outdoor factory sites, ship yards, and air bases. For the sake of cost reduction, processing efficiency and power efficiency it should be avoided having to temporarily operate terminals intended for the support of a certain (maximum) data rate at a very much higher air interface rate.

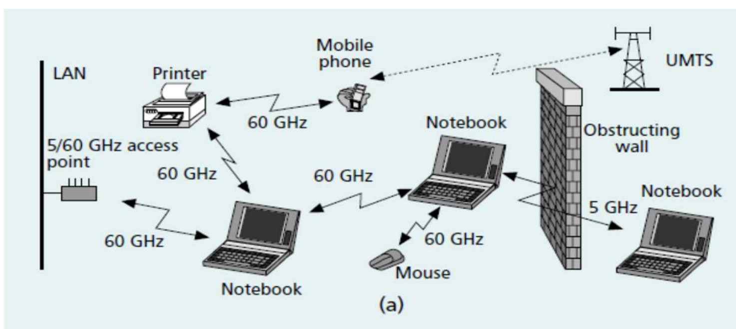

Figure 2: 5/60 GHz system scenario in office environment

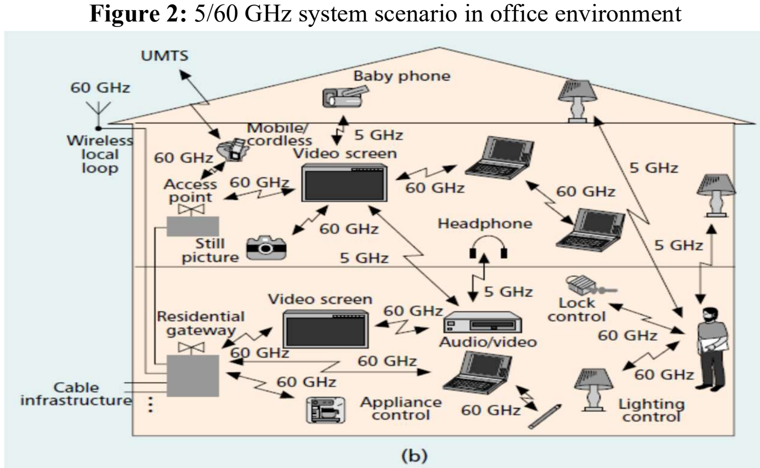

Figure 3: 5/60 GHz system scenario in home environment

V. Standardization

Currently, there is only one standard addressing the 60 GHz band and that is the IEEE 802.16 standard for Wireless MAN which covers 10 to 66 GHz [4]. It concerns a last-mile broadband wireless connectivity alternative to fiber-based DSL. In the design of the physical layer, line-of-sight (LOS) propagation was deemed a practical necessity. Therefore, the standard specifies a single carrier interface which is designated "Wireless Man-SC". This opens the door for the creation of fixed Broadband Wireless Access, which could provide license-free network access support to buildings with speeds that approach those offered by high-speed fiber optic networks, which saves tremendous initial investments in the deployment of last-mile networking technology.

Recently a paradigm shift from "60 GHz is strictly for LOS operation" to "60 GHz may also be suitable for non-LOS situations under certain circumstances" has gained considerable support. As a first step in the creation of a standard, the IEEE has formed an interest group to explore the use of the 60 GHz band for wireless personal area networks (WPANs), which typically have to support non-LOS operation with a range of 10 meters. The IEEE 802.15.3(TM) Millimeter Wave Interest Group (mmWIG) was formed in July 2003 as part of an effort to develop a millimeter-wave-based alternative physical layer for the IEEE high-rate WPAN standard, IEEE 802.15.3TM 2003.

5.1 Application Of Higher Order Frequency In Communication Systems

The work will present a brief summary of possible applications for a 60 GHz communication system.

- Wireless LAN bridge, e.g., for interconnecting gigaethernet lans in different 100–1000 buildings
- Wireless TV high-resolution recording camera
- Wireless trading terminal having multiple video channels that can be viewed simultaneously for monitoring world news next to stock quote information
- Wireless news tablet, a very thin, possibly flexible device that provides the user with a newspaper, e.g., the possibility of activating images to see
- Video impressions
- Wireless (high-quality) videoconferencing
- Wireless ad-hoc communications, i.e., direct communication between notebooks, between notebook and nearby printer, etc.

VI. Conclusion

There exists an ever increasing supply of, and demand for, broadband multimedia applications calling for an ever increasing capacity of wireless networks. Finally, this will cause a demand for wireless transfer capacity far in excess of what can be accommodated in the currently used bands at 2.4-2.5 GHz and 5.2-5.8 GHz [1]. An obvious solution to this problem is to resort to the 60 GHz band, where bandwidth is abundantly available. In particular, for dense local communications, the 60 GHz band is of special interest because of the specific attenuation characteristic due to atmospheric oxygen of 10-15 dB/km. The 10-15 dB/km regimes make the 60 GHz band unsuitable for long-range (> 2 km) communications so that it can be dedicated entirely to a short-range (< 1 km) communications. For the small distances to be bridged in an indoor environment (< 50 m) the 10 to 15 dB/km attenuation has no significant impact. The specific attenuation is excess of 10 dB/km occurs in a band-width of about 8 GHz centered around 60 GHz. Thus, from physical point of view, there are about 8 GHz band widths available for dense wireless local communications. This makes the 60 GHz band of utmost interest for all kinds of short-range wireless communications.

In the United States, the Federal Communications Commission (FCC) set aside the 59-64 GHz frequency band for general unlicensed applications [2]. This was the largest contiguous block of radio spectrum ever allocated. FCC rules allow 10 Watts of equivalent isotropic radiated power in this band, which complies with a maximum power density of 9μW/cm^2 at 3 meters distance. This means that 20dBm transmit power would be the legal power limit with an antenna having 20 dBi gain. Commercial power amplifier GaAs MMIC's are now available that can produce 16 dBm of transmit power with good linearity. In Japan, there was a new regulation in August 2000 for high speed data communication. The frequency range is 54.25-59 GHz for licensed use with a maximum output power of 100mW and a minimum antenna

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gain of 20dBi and 59–66 GHz for *unlicensed* use with a maximum output power of 10mW and a maximum antenna gain of 47dBi. In Europe, frequency is allocated for mobile in general in the 59-66GHz band. No specific recommendation or decision has been issued yet in this mobile frequency band.

However, the 54-66 GHz band is considered by CEPT as a main priority issue; in a recommendation document [3] CEPT considers: "the high-frequency re-use achievable in the oxygen absorption band reduces the requirement for sophisticated frequency planning techniques and offers the possibility of a pan-European deregulated telecommunications environment for various low power, low cost, short-range applications" and "there is an urgent need to identify and harmonize civil requirements in the frequency range 54–66 GHz". An important statement that has to be made here is that Europe should follow the US and Japan by opening a significant part of this band for *unlicensed* use, because license free is an important condition for promoting 60 GHz systems towards the market!

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